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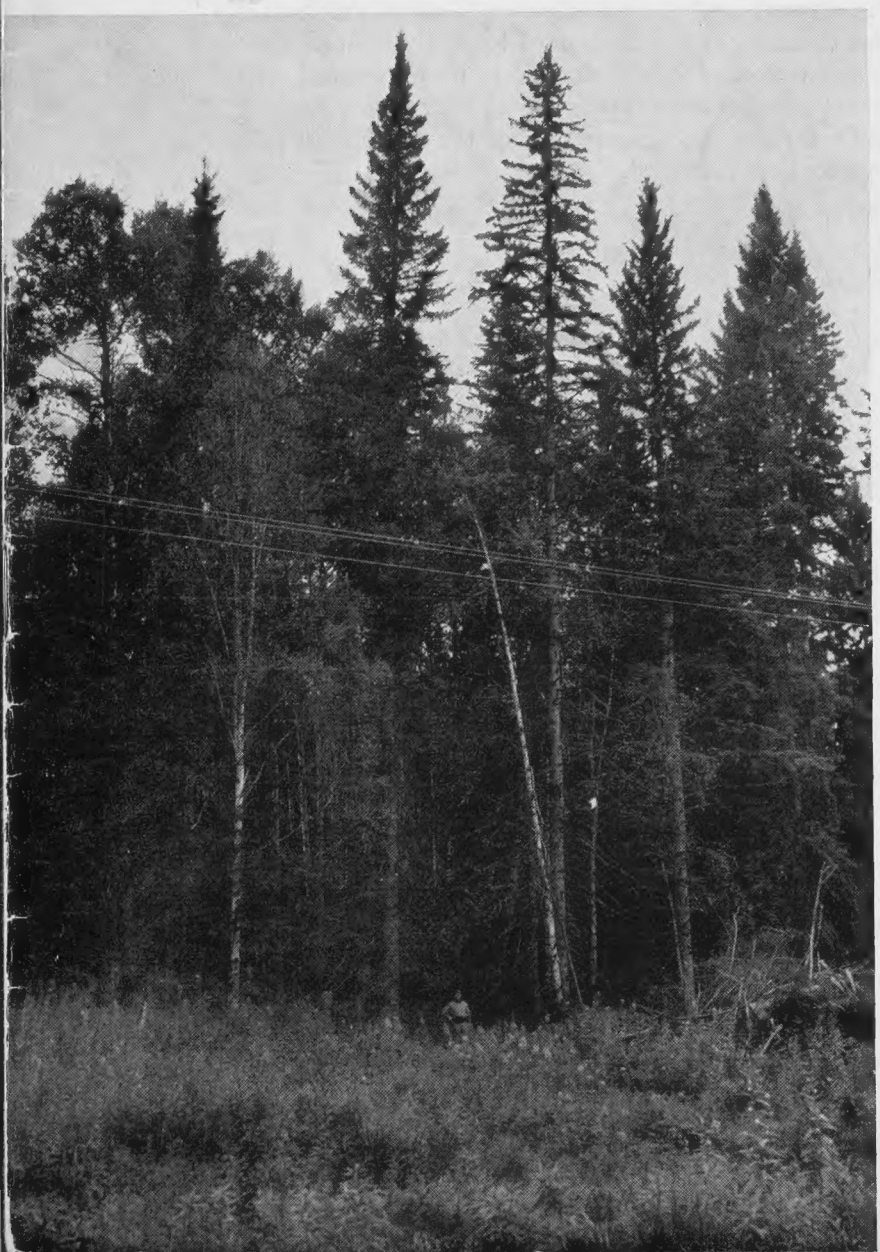
A Forest Land Classification for the Mixedwood Section of Alberta



by
P. J. B. DUFFY

Department of Forestry Publication No. 1128
1965

Sommaire et conclusions en français

ABSTRACT

A field survey was devoted to the description and classification of soils and forest productivity in the accessible portion of the Mixedwood Forest (white spruce-trembling aspen) of Alberta. The basis for the classification is the distinction between different parent materials divided according to moisture status and the attendant differences in forest growth. Using white spruce maximum dominant height at 80 years as a site index, parent materials are ranked in a forest land productivity classification. Prime sites for spruce are on moderately well-drained to poorly drained soils; less productive sites occur on well drained to poorly drained soils and the poorest merchantable stands are on very poorly drained and on rapidly drained soils. Some uses of the classification in forest management are discussed.

Published under the authority of
The Honourable Maurice Sauvé, P.C., M.P.,
Minister of Forestry
Ottawa, 1965

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1965

Catalogue No. Fo 47-1128

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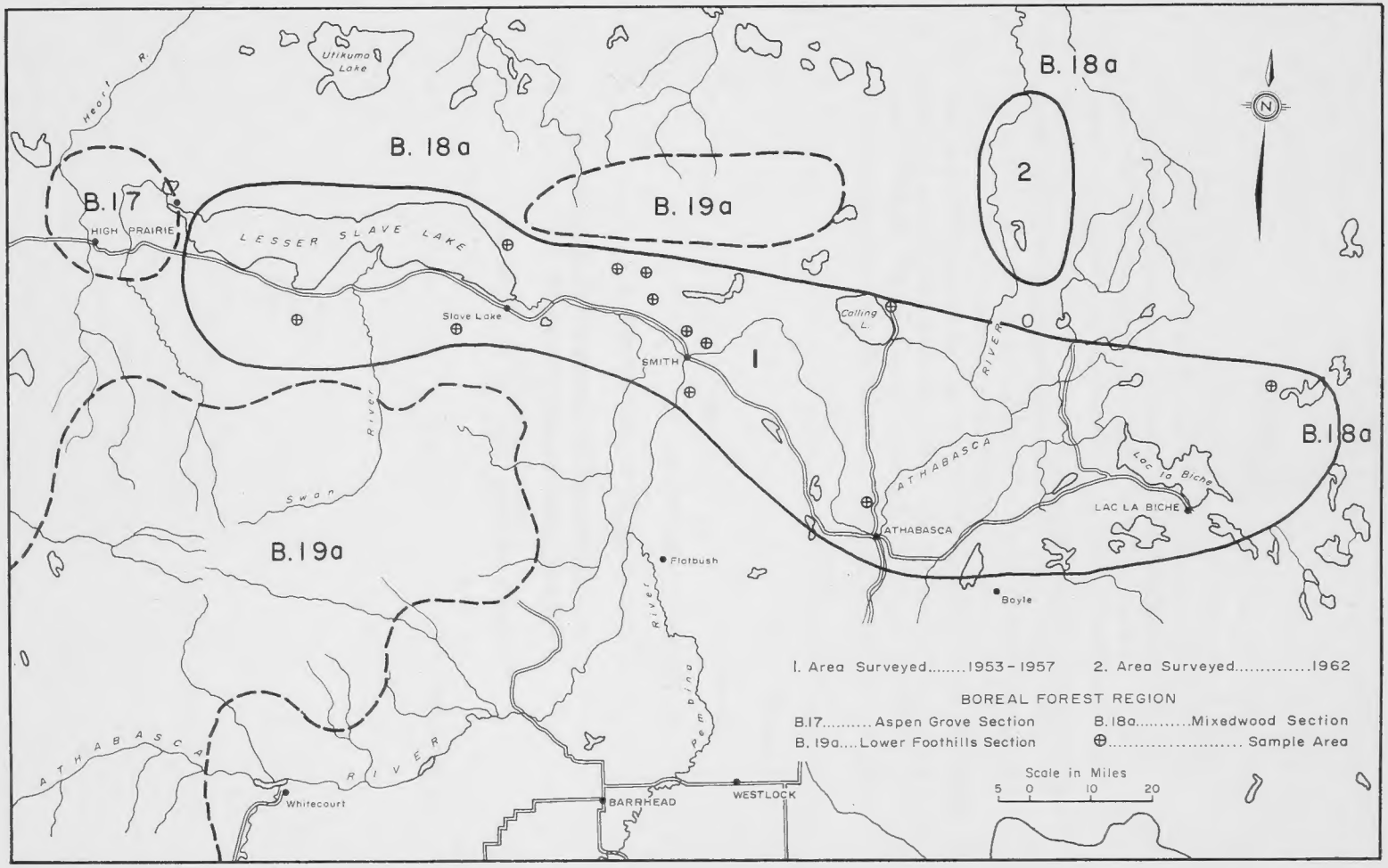

Frontispiece — The study area.

A Forest Land Classification for the Mixedwood Section of Alberta[1]

by

P. J. B. Duffy[2]

INTRODUCTION

Considerable interest has developed in forest land classification in Alberta over the last decade. Increased forest use in the Mixedwood Section (B.18a) of the Boreal Forest has encouraged research into the description and classification of productivity of the important sites[3]. Progress has been substantial but the task has been made difficult by the diversity, inaccessibility and extent of the area and by the mixed, under-stocked, and unevenaged forests.

The purpose of this paper is to present a preliminary differentiation of forest sites in a selected study area in the Mixedwood Forest and to provide a tentative classification which can be useful in the field in the planning of forestry operations and which can aid photo-interpretation in forest land classification. Parent materials were identified from a study of land form, drainage and soil texture. The hypothesis is that forest stand composition and productivity in terms of maximum white spruce[4] height growth at 80 years are characteristic for drainage classes of different parent materials.

Acknowledgements

This paper is based, in part, on the extensive field studies of Mr. J. Quaite, formerly forestry officer in the Alberta District, Department of Northern Affairs and National Resources. Mr. Quaite initiated the study and directed the field work from 1952-1956. The author continued the study to 1962.

The author acknowledges with thanks the advice and assistance from the staffs of the Alberta Soil Survey, Alberta Department of Lands and Forests and from the Department of Soil Science, University of Alberta.

Dr. R. T. Ogilvie, formerly research officer, Department of Forestry, assisted in the compilation and analysis of the ground vegetation data.

DESCRIPTION OF THE STUDY AREA

The study area (Frontispiece) is located in a portion of the Mixedwood Section of the Boreal Forest Region in the Lesser Slave Lake-Athabasca River—Lac la Biche lowland. The Mixedwood includes most of Alberta between 54° and 58° of latitude and between 1,200 and 2,500 feet of elevation above sea level and covers an area of about 79,800 square miles (Aldred, 1964).

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[1] Presented at meetings of the Western Society of Soil Science, American Association for the Advancement of Science, Vancouver, B.C., June 24, 1964.

[2] Research Officer, Department of Forestry of Canada, Calgary, Alberta.

[3] Definitions of terms are given in a glossary in Appendix I.

[4] For botanical names of trees see: Native trees of Canada, Dept. Forestry Bull. 61. Sixth Edition. 1961.

Climate

The study area has a long cold winter and a relatively short warm summer. Annual precipitation varies from 15 to 18 inches, 65 per cent of which falls between April and October inclusive; June and July are the wettest months. A climatic summary is given in Table 1.

Muttit (1961) has shown that during the warmer months, areas of higher elevation receive greater rainfall than surrounding lowlands. Higher rainfall occurs in the Swan Hills area, on the Pelican Mountains and on high ground north-east of Lac la Biche. The frost-free season in the study area varies from 59 days at Athabasca to 106 days at Lac la Biche. Frequent invasions of cold, polar continental air together with calm, clear weather bring late spring and early fall frosts.

Topography and Soils

The topography in the study area is a result of Continental glaciation and subsequent erosion of the undivided Early Upper Cretaceous bedrock (Anon., 1951) which underlies most of the area and sandstones, shales and conglomerates in some portions (Feniak, 1944). The common landtypes are alluvial lowlands, ponded and lacustrine flats, ground moraines, aeolian deposits and areas of organic accumulations, chiefly muskegs. Merchantable forest stands are found on all landtypes except the muskegs.

Parent materials vary greatly from the high uplands to the riverine sites. Nearby mountains (Marten Mountain, Swan Hills) are capped with pre-glacial gravels and the slopes are mainly under a till mantle. In the lowlands extensive lacustrine flats are remnants of drained post-glacial lakes. Aeolian deposits are situated south and east of some old river and lake beds. In the bottomlands alluvial and lacustrine parent materials mark recent water courses. The origin of parent materials in portions of the Mixedwood have been discussed by Bayrock (1962) and by Pawluk (1961) and the glacial history of parts of the study area can be traced from the works of Henderson (1959) and Stalker (1960). Post-glacial lake formations were described by Taylor (1960).

There are no published soil survey maps and reports for the study area but soils in the well-drained situations do resemble those on the High Prairie—McLennan Sheets as described by Odynsky, Wynnyk, and Newton (1952) and for convenience they have been so designated in this paper.

Most of the soils in the study area are classed in the Orthic Subgroup of the Grey Wooded Great Group (National Soil Survey Committee of Canada, 1963:34). They are characterized by organic surface horizons (L, H)[5] with a lighter colored eluvial horizon (Ae) and with an illuviated Bt horizon which has a higher clay fraction than the upper horizons.

Recent alluvial soils without discernible horizons are common; they are classed as regosolic soils, and are defined as "well and imperfectly drained soils that lack discernible horizons or in which horizon development is limited to an organic-mineral surface horizon (Ah) or to organic surface horizons (L-H) less than 12 inches thick" (N.S.S.C.C., 1963:47). Gleysolic soils are common in areas of a high fluctuating water table. Soils in the Gleysolic Order may have an organic horizon of less than 12 inches in thickness (compacted or solid), an Ah horizon or both, or may lack these surface horizons (N.S.S.C.C., 1963:49).

[5] Horizon nomenclature follows that used in the classification of Canadian soils (N.S.S.C.C., 1963).

TABLE 1. CLIMATIC SUMMARY FOR STATIONS IN THE MIXEDWOOD SECTION (B.18A) OF ALBERTA.†

Station	Elevation, in feet above sea level	No. of years of record		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual Temp., °F.	Mean Annual Precip., Inches	Average frost free period (days)
Slave Lake	1921	31	T.*		7.1	20.5	36.4	49.0	55.7	61.3	57.6	48.6	38.2	21.5	7.1	33.9	—	78
			P.**	.99	1.05	.92	.91	1.72	2.38	3.12	3.12	1.71	1.15	1.08	.94	—	18.30	
Athabasca	1692	29	T	—	—	—	—	—	—	—	—	—	—	—	—	33.8	—	59
			P	—	—	—	—	—	—	—	—	—	—	—	—	—	17.38	
Lac la Biche	1837	14	T	1.0	7.5	20.2	33.2	50.6	57.9	62.7	59.1	45.07	40.1	22.5	9.4	34.6	—	106
			P	1.07	.69	.76	.80	1.80	2.47	2.92	2.42	1.36	.90	1.08	1.03	—	17.30	
McMurray	1216	34	T	−6.2	0.5	15.4	34.4	48.8	56.2	61.6	58.0	47.8	36.5	15.0	−1.8	30.5	—	67
Airport			P	.83	.62	.85	.77	1.39	2.11	3.08	2.25	1.67	.97	.95	.83	—	16.32	
Wabasca	1784	23	T	—	—	—	—	—	—	—	—	—	—	—	—	33.9	—	105
			P	—	—	—	—	—	—	—	—	—	—	—	—		14.93	
Keg River	1405	—	T	−2.4	1.6	18.6	34.1	48.2	55.6	59.9	57.0	48.1	37.7	15.4	−0.8	31.1	—	57
			P	.72	.76	.72	.76	1.80	1.76	2.16	1.74	1.40	.98	1.09	1.06	—	14.95	

† Lindsay, D. Unpublished data. Alberta Research Council, Soil Survey Section, Edmonton.

*T. — Temperature

**P. — Precipitation

The Forest

The Mixedwood Section of the Boreal Forest Region is typically a white spruce-trembling aspen forest. Both species have broad soil tolerances. The best spruce (95 feet high at 80 years) are found on moderately well-drained alluvial soils where they grow in mixture with white birch, balsam poplar and balsam fir. Because of differences in soil conditions and stand history, stocking levels and spruce-hardwood percentages vary widely.

Balsam poplar grows best on alluvial lowlands; dominant heights of 90 feet are common. Trembling aspen and white spruce grow in association and balsam fir is present in mature and overmature stands.

Pure jack pine stands occur on aeolian and dry alluvial soils. Black spruce and jack pine share sites on moist lacustrine soils with a sand cap and on moderately well-drained upland tills.

Poorly drained till plains and wet bogs are very extensive in the Mixedwood Section, especially in the broad lowlands north of Lesser Slave Lake and the Athabasca River and north of Lac la Biche. Pure stands of black spruce occupy these sites; tamarack and white birch may grow in association.

Rowe (1959) has written a description of the Mixedwood Section which is useful for comparisons with the adjoining forest sections.

FIELD AND LABORATORY METHODS

Area I (Frontispiece) was studied in a reconnaissance survey during 1953, 1954, 1956 and 1957 to describe the main surface materials and white spruce growth. No sample design was followed but various surface materials were examined. In 1953 and 1954, growth and yield plots were located on well-drained upland till and recent alluvium sites. In 1956 and 1957, emphasis in the field sample was placed on the dry (aeolian deposits, gravel outwashes) and wet sites (lacustrine lowlands and bog fringes). A total of 414 temporary one-fifth acre growth and yield plots were described and tallied. The following data were recorded:

1. Terrain and soil profile descriptions, including soil permeability, moisture, status and local climate (Hills, 1952). Soil samples were taken from each important horizon for particle size analysis.
2. A diameter tally of all trees over 0.6 inches d.b.h., by species and inch classes.
3. Total heights of 10 dominant trees, for the construction of height-age curves, and sufficient heights of trees of other diameter classes to construct height-diameter curves.
4. Stem analysis of from three to six dominant white spruce trees on 155 plots; only trees with constant diameter growth were felled, sectioned and measured.
5. Lists of ground vegetation species within 15 feet of the soil pit with estimates of the percentage of the ground covered, by species.

Laboratory analyses included:

(a) Particle size analysis of soil samples using a modified Bouyoucos hydrometer method (Bouyoucos, 1951),

(b) soil pH using an electric Beckmann-Glass Electrode pH meter,

(c) presence of lime; using a dilute solution of hydrochloric acid.

In 1962, a co-operative study was made with the Forest Surveys Branch of the Alberta Department of Lands and Forests in Area 2 (Frontispiece).

Several hundred plotless samples of basal area and stand volume were taken over a variety of parent materials and dominant heights of white spruce and other species were recorded. The 1962 survey is the subject of a forthcoming report but it did afford the opportunity to try the land classification from Area I in a new locality.

ANALYSIS OF DATA

Total and merchantable stand volumes (cubic feet per acre) were compiled from plot tallies using the tables of Blyth (1952) and MacLeod and Blyth (1955). Height-age and height-diameter curves for white spruce were prepared for all stem analysis plots. The stand volume data and white spruce height-age curves were then grouped by parent material and drainage classes to examine mean productivity values for different physiographic conditions.

Differences between mean height-age curves permitted a preliminary classification of site types. However, the variation of data about the mean height curves for several sites was great. For instance, the array of curves for the well-drained, upland till sites showed almost as much variation as existed over the total range of sites in the Mixedwood Forest. Most of the scatter was attributed to the following:

1. variation in productivity potential within a physiographic site as recognized by land form, drainage and soil texture,
2. species composition of the forest,
3. differences in stocking level.

Plots from fully stocked, free growing, white spruce-trembling aspen stands on important parent materials were used in the land classification portion of the study. Maximum dominant height of white spruce at 80 years was used as the site index. This index was based on the growth of superior stems and therefore represented the best available estimate of forest land potential for the spruce-aspen forest. For sample plots with stands under 80 years of age, a height-age factor was used for classification. The factor was the arithmetic expression for the slope of the height-age curve between 15 feet height and 60 years of age which is almost a straight line.

The best white spruce heights were selected from 80 plots from a range of important parent materials. By ranking the height data in descending order the most productive sites were identified. No tests of significant differences were made and so the arbitrary nature of the analysis must be recognized.

A number of plant communities were identified. They must be considered as tentative because the study plots were selected on the basis of physiography and were therefore not always typical examples of a single plant association.

RESULTS

The data for the best white spruce growth were summarized by parent material and soil moisture status and were ranked in terms of decreasing productivity as a basis for a preliminary land classification (Table 2). After partitioning the range of heights into four classes the best white spruce heights (85 to 95 feet at 80 years) are seen to occur on well drained to imperfectly drained sands and loams. Growth of approximately one foot per year (75 to 84 feet at 80 years) occurs on heavier textured soils (clay, clay loam) with imperfect drainage or on dry sandy soils. Less productive sites (50 to 74 feet at 80 years) are on wet clays and dry sands. The poorest growth (less than 50 feet at 80 years) occurs on muskeg sites.

The classification is illustrated as a physiographic continuum in Figure I. The soils with a middle range of moisture and texture characteristics furnish the best conditions for white spruce growth. Growth drops off on the dry and wet ends of the continuum.

The schematic profile of forest vegetation and soils in Figure 2 shows the relative positions of the important forest sites.

Productivity Class I includes the best white spruce sites, on which a range of maximum height growth of over one foot per year (above breast height) is attained. In loam and clay loam soils the moisture status is well drained to moderately well

TABLE 2. PHYSIOGRAPHIC SITES OF THE MIXEDWOOD SECTION, BOREAL FOREST, RANKED ACCORDING TO MAXIMUM DOMINANT HEIGHT OF WHITE SPRUCE AT 80 YEARS. BASIS: 80 ONE-FIFTH ACRE PLOTS.

Parent Material	Texture of Parent Material	Soil Moisture Status	Site Index at 80 yrs. (feet)
Productivity Class I: 85 – 95 Feet at 80 Years			
1. Lowland alluvial (Alluvium, High-Prairie)*	Stratified sand and silt	Moderately well-drained to poorly drained	95
2. Alluvial-lacustrine (Kathleen)	Stratified sandy loam, loam, and silt loam	Well drained to imperfectly drained	90
3. Till: (Braeburn)	Clay loam to heavy clay loam	Well drained to moderately well drained	90
4. Till: with alluvial cap (Braeburn)	Sandy loam to heavy clay loam	Well drained to imperfectly drained	87
Productivity Class II: 75 - 84 Feet at 80 Years			
5. Lacustrine: (Donnelly)	Clay loam to clay	Well drained to imperfectly drained	84
6. Alluvial-lacustrine (Kathleen)	Sand, silt, clay	Imperfectly drained to poorly drained	84
7. Till: (Braeburn)	Clay loam to heavy clay loam	Moderately well-drained to poorly drained	84
8. Alluvium: dry elevated terraces (Heart)	Stratified sand and silt	Rapidly drained to well drained	82
9. Till (clay-rich): (Snipe)	Heavy clay loam to clay	Imperfectly drained to poorly drained	78
Productivity Class III: 50 - 74 Feet at 80 Years			
10. Lacustrine: (Kathleen)	Clay	Poorly drained	74
11. Aeolian: sheets and dunes (Heart)	Sand	Rapidly drained	60
Productivity Class IV: Less than 50 Feet at 80 Years			
12. Muskeg	Organic cap over heavy clay loam to clay	Very poorly drained	<50

* Some of the soils in the study area resemble mapped soil series (Names in brackets) on the High Prairie and McLennan Sheets (Odynsky, Wynnyk and Newton, 1952).

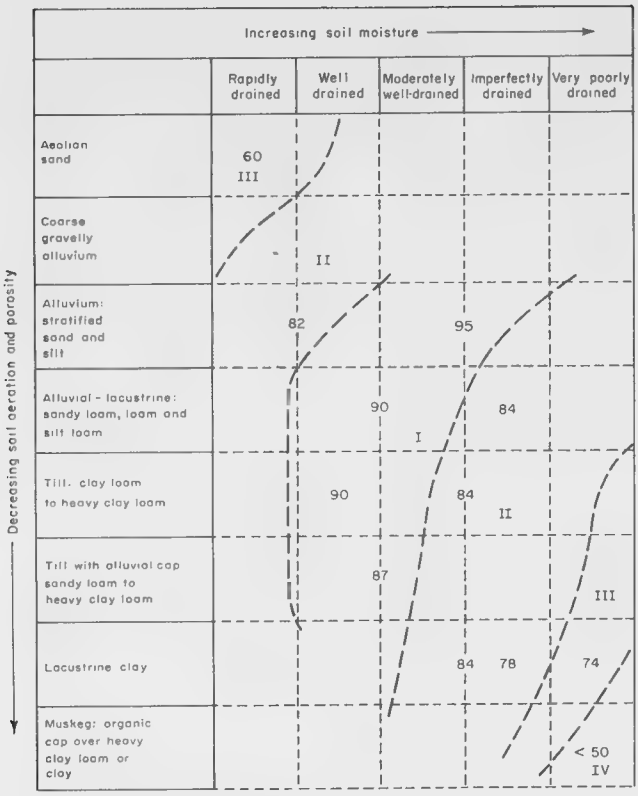

Figure 1. Maximum dominant height growth (in feet) for white spruce at 80 years by parent material and soil moisture status. Oblique lines separate the productivity classes given in Table 2.

drained depending upon position. The shrub-herb-moss community is characteristic on the moderately well-drained sites. Typical species are *Viburnum edule*[6], *Rosa acicularis, Aralia nudicaulis, Mertensia paniculata, Lonicera involucrata, Linnaea borealis, Cornus canadensis, Mitella nuda, Maianthemum canadense, Trientalis borealis, Hylocomium splendens*[7], *Pleurozium schreberi*, and *Hypnum crista-castrensis*. The shrub-horsetail-moss community occurs on the poorly-drained, lowland alluvium sites. This community is dominated by *Equisetum arvense, E. sylvaticum*, and *E. pratense*, as well as *Petasites palmatus, Cornus stolonifera, Ribes lacustre, R. triste, Rubus strigosus, R. pubescens*, and the mosses *Hylocomium splendens, Pleurozium schreberi*, and *Hypnum crista-castrensis*.

In Productivity Class II the rate of maximum height growth for white spruce dominants is approximately one foot per year (75-84 feet at 80 years). The characteristic vegetation types are the shrub-horsetail-moss community, and, in the wetter moisture regimes, the Labrador tea-cranberry community. The latter is composed of *Ledum groenlandicum, Vaccinium vitis-idaea, V. myrtilloides, Gaultheria hispidula, Equisetum* spp., and some mesic species of shrubs and mosses. On poorly drained, alluvial-lacustrine sites near Lesser Slave Lake there are local occurrences of a fern community with *Dryopteris disjuncta, D. spinulosa*, and *Pteretis nodulosa* and a devil's club community with an abundant cover of *Oplopanax horridum* as well as *Rubus pubescens* and *Dryopteris* spp.

[6] Names of vascular plants follow Moss (1959).

[7] Names of mosses follow Watson (1959).

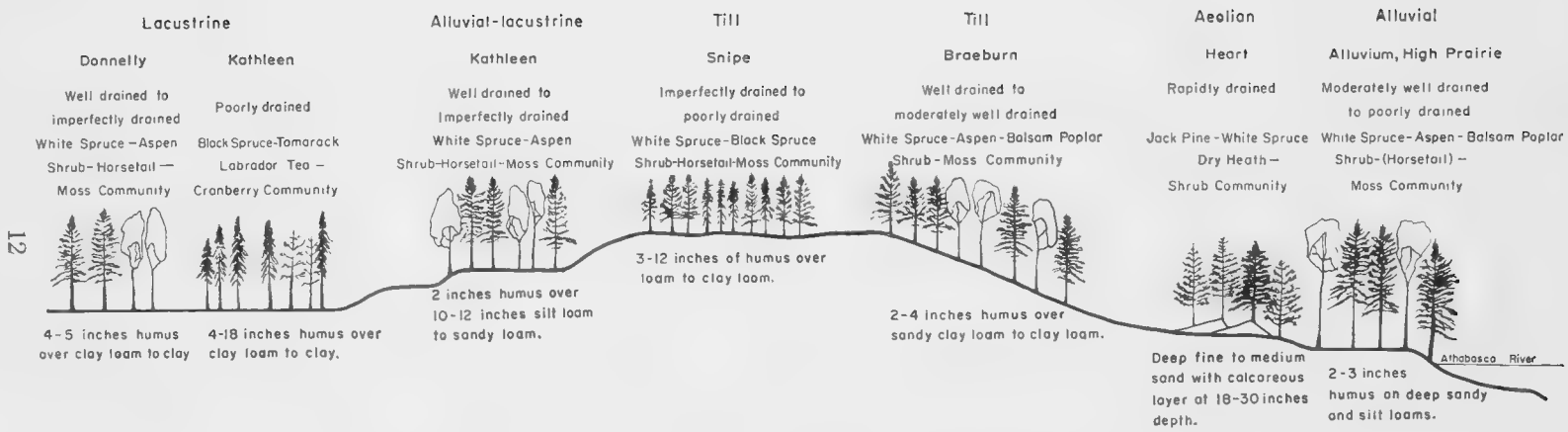

Figure 2. Forest and soil relationships, schematic section near Smith, Alberta.

Productivity Class III comprises wet alluvial-lacustrine as well as dry aeolian sites. Dominant white spruce reach 50-74 feet at 80 years of age. The wet sites are typified by the Labrador tea-cranberry community. Black spruce and tamarack often share such sites with white spruce. On dry aeolian soils jack pine often occurs with white spruce. The vegetation type is the dry heath shrub community, composed of *Arctostaphylos uva-ursi*, *Vaccinium caespitosum*, *V. myrtilloides*, *Polytrichum* spp., and abundant *Cladonia* spp.

Productivity Class IV comprises muskegs in which white spruce is associated with black spruce, tamarack and white birch. The Labrador tea-cranberry-peat moss community is typical of these sites. Here *Sphagnum* spp. assume the dominant role, with *Ledum groenlandicum*, *Vaccinium vitis-idaea*, *Chiogenes hispidula*, *Caltha palustris*, and some occurrence of *Equisetum* spp.

The parent materials in Productivity Classes I and II support most of the economically important forests in the study area. A summary of productivity data from 68 representative plots on some of the parent materials is given in Table 3. The table is descriptive, and gives per acre figures for well-stocked spruce-aspen stands with some variation in stocking level and species composition on different soils.

DISCUSSION

Tree growth and species composition in the study area are linked with parent material and drainage. The relationships are only general; this is because of the reconnaissance survey-type sampling which was employed. The classification in Table 2 is a ranking of physiographic sites by dominant height growth of white spruce. Different numbers of observations were taken on different parent materials, hence valid statistical tests were not made. As the need for more precise forest land classification arises, the forest might first be stratified by parent materials and drainage classes and then an equal number of spruce growth samples should be taken from each parent material-drainage class combination (Duffy, 1964a).

White spruce height growth in the study area is best on moisture-retentive clay loam soils and on sites which, because of position, have a continuing supply of moisture from laterally moving ground water or from the water table. Such sites are not prone to summer droughts which occur in Alberta periodically and which have been studied in conjunction with available soil moisture in another section of the Boreal Forest (Duffy, 1964b).

White spruce height growth decreases on sites which are wetter or drier than the optimum mesic sites mentioned above. Kirby (1962) also found this in Saskatchewan. There the best white spruce growth occurred on moist steep slopes where the soil moisture is maintained by ground water seepage; intermediate growth was observed on fresh to moist till and on alluvial-lacustrine soils, and poor growth was recorded on wet, poorly drained situations.

White spruce grows on almost all soils in the study area except dry coarse sands and wet bogs. Its tolerance to extremes of soil moisture is related to a flexible rooting habit. A taproot form occurs on well drained sites on upland tills, dry alluvium and aeolian sands. The taproot and other vertical roots have access to subsurface moisture; well developed lateral roots receive moisture from the upper soil horizons. On poorly drained and wet sites (lacustrine and some lowland alluvium) one or more whorls of lateral roots develop from the stem as the ground cover of moss becomes deeper. These replace lower lateral roots which are in the zones of excessive moisture. This multi-layered root form is seen on white spruce trees growing on soils with high water tables.

Several applications of the proposed classification are suggested. In a forest land inventory survey of a 1,000 square mile management unit north of Lac la Biche

TABLE 3. SUMMARY OF FOREST LAND PRODUCTIVITY LEVELS FOR THE MAJOR PARENT MATERIALS IN THE STUDY AREA*, **

Parent materials	Number of Plots	Stand Age	Basal area/acre; sq. ft.		Total vol./acre; cu. ft.†		Merch. vol./acre; board ft.†		Site Index at 80 yrs. ft.
			Conifers	All species	Conifers	All species	Conifers	All species	
Productivity Class I									
Lowland alluvial (Alluvium, High Prairie)††	8	110 ± 20	171 ± 55	197 ± 15	6,459 ± 1,995	7,241 ± 444	33,913 ± 11,072	36,233 ± 4,214	95
Alluvial-lacustrine (Kathleen) well-drained	10	104 ± 14	151 ± 29	203 ± 12	5,081 ± 1,292	6,833 ± 323	22,868 ± 8,007	29,603 ± 3,139	90
Till (Braeburn) well drained	16	106 ± 25	144 ± 35	179 ± 20	4,648 ± 968	5,625 ± 786	21,433 ± 6,922	24,950 ± 5,957	90
Till with alluvial cap (Braeburn)	11	120 ± 83	158 ± 52	211 ± 31	5,368 ± 1,690	7,029 ± 2,244	25,646 ± 11,198	33,069 ± 13,751	87
Productivity Class II									
Lacustrine (Donnelly) well drained	3	85 ± 16	154 ± 39	190 ± 21	4,265 ± 1,109	5,373 ± 292	15,242 ± 7,887	17,120 ± 5,263	84
Alluvial-lacustrine (Kathleen) poorly drained	8	108 ± 28	156 ± 41	177 ± 19	5,075 ± 1,489	5,609 ± 748	22,695 ± 9,017	24,317 ± 6,426	84
Till (Braeburn) poorly drained	6	105 ± 19	145 ± 18	176 ± 12	4,660 ± 560	5,479 ± 366	20,561 ± 3,642	23,877 ± 2,443	84
Alluvium (terrace) (Heart)	6	104 ± 3	149 ± 2	163 ± 3	4,436 ± 20	4,757 ± 6	17,380 ± 2,165	18,322 ± 2,513	82

* Basis for table: 68 one-fifth acre growth and yield plots.

**Range of two standard deviations about the mean excepting the lacustrine condition where total range is given.

† References: For white spruce: Blyth, A.W. (1952). For aspen: MacLeod, W.K. and A.W. Blyth (1955).

††See footnote under Table 2.

(Area 2 in Frontispiece), white spruce sites were rated according to the classification in Table 2. It was found that the classification was useful without modification as maximum dominant heights of white spruce on the principal parent materials in Area 2 fell within the Productivity Classes for data from Area 1.

Seeding and planting operations are on the increase in the Mixedwood Forest. White spruce seedlings are being established under pure aspen stands which are presently unmerchantable. It is suggested that the proposed classification be employed in these forest regeneration operations; a greater return will be realized from plantations situated on sites in Productivity Class I (Table 2) than on sites situated lower in the table. In this regard Denyer[8] has found that yellow stringy butt rot (*Flammula alnicola* (Fr.) Kummer) occurred more frequently in white spruce trees of all ages on recent alluvium, till and dry elevated alluvium sites than on dry aeolian soils and poorly drained lacustrine sites. Moist to wet soils with a non-calcareous parent material and an acid Ae horizon furnished suitable conditions for the establishment of *F. alnicola*. The rot accounted for 17 per cent of the total decay volume in white spruce in Alberta and was the most important butt rot in the Smith-Lesser Slave Lake study area.

Scarification for improved regeneration is the subject of current operational trials in the Mixedwood Forest. Some sites are unsuitable for scarification because of heavy ground vegetation or poor drainage. Where topography and soil texture permit good drainage on prime sites which are problematic for spruce regeneration, scarification is being tried. Problem sites are found on lowland alluvium, well-drained alluvial-lacustrine and till.

Windthrow is a problem on soils with high water tables where white spruce develops a plate-like root system. Lacustrine and alluvial-lacustrine (ponded) sites are in this category. Following heavy rains in June and July, residual spruce in partially cut-over areas on these sites are often prone to windthrow.

Construction of access roads for logging and oil exploration in the Mixedwood Section is complicated by a lack of suitable materials for roadbeds, by wet seasons, and by poor drainage. The main sources of aggregate materials (sand and gravel) are in coarse, gravelly outwash and alluvial terrace deposits and in eskers. These landforms may be identified on air-photographs but ground checking is necessary to confirm the suitability of the sands and gravels. Occasionally thin veneers of fine textured soils (silt loam to clay loam) cap otherwise satisfactory deposits of clean gravel. Beach deposits of sand and gravel are not common in the study area, however they do offer a good road building chance on the shore of Lesser Slave Lake where they are mapped as the Clouston and Grouard soil series (Odynsky, Wynnyk, and Newton, 1952). Another beach line remnant with good roadbuilding potential lies east of the present shore of MacMillan Lake north-west of Lac la Biche. Some photo-typing is illustrated in Appendix II together with a preliminary photo interpretation key for the identification of parent materials in the study area.

The Alberta Soil Survey has issued soil reports and maps for a large portion of the Mixedwood Section which lies south and west of the study area. These include the Rycroft and Watino Sheets (Odynsky and Newton, 1950), High Prairie and McLennan (Odynsky *et al.*, 1952), Grande Prairie and Sturgeon Lake (Odynsky *et al.*, 1956) and the Beaverlodge and Blueberry Mountain Sheets (Odynsky *et al.*, 1961). Preliminary soils reports are available from the Alberta Soil Survey Helicopter Project the purpose of which is the location of potentially arable land in Northern Alberta. Most of the Mixedwood Section has been extensively surveyed in this project and Lindsay *et al.*, (1958, 1959, 1960, 1962) have summarized climatic data and soils analyses and have suggested soil series names for some soils. Because the

[8] Denyer, W.B.G. 1960. The biology of *Flammula alnicola* (Fr.) Kummer. Dept. of Forestry, Canada, Forest Biology Division. Interim Report. (Unpublished).

identification of surface materials and drainage classes are common to soil survey and to forest land classification, these published soils reports provide a useful base for forest land classification as has been demonstrated for the Rocky Mountain House Sheet in the Foothills Section of Alberta (Duffy, 1962).

SUMMARY AND CONCLUSIONS

White spruce growth on different soils was studied in an extensive reconnaissance of accessible portions of the Mixedwood Section. Soils and drainage data were correlated with spruce height growth as a basis for a preliminary forest land productivity classification.

It was found that:

1. A suitable site index for white spruce is maximum dominant height at 80 years.
2. The best spruce sites (85-95 feet at 80 years) are on well-drained soils on alluvial, alluvial-lacustrine, and till parent materials.
3. Less productive sites (75-84 feet at 80 years) occur on imperfectly drained to poorly drained soils on lacustrine clays, alluvial-lacustrine parent materials and on rapidly drained soils on elevated alluvial terraces.
4. Poorest spruce growth (50-74 feet at 80 years) is found on wet, poorly drained clay soils and on dry aeolian sands as well as on very poorly drained muskeg sites (less than 50 feet at 80 years).

The classification is a tentative categorization of forest land for a portion of the Mixedwood Section and ranks physiographic sites in decreasing order of productivity according to maximum dominant height growth in spruce. The parent material-drainage class combinations should be differentiated because of their different forest capabilities.

SOMMAIRE ET CONCLUSIONS

L'on a étudié la croissance de l'épinette blanche, en sols différents, au cours d'un vaste relevé de reconnaissance des forêts accessibles de la zone des peuplements mixtes. On a établi la corrélation entre les données relatives aux sols et au drainage et la croissance en hauteur de l'épinette, en vue de procéder à un classement préliminaire des terres forestières de la région, d'après leur fertilité.

L'auteur a fait les constatations suivantes:

1. La hauteur maximum de l'étage dominant à 80 ans peut convenablement servir d'indice de fertilité des sols favorables à la croissance de l'épinette blanche.

2. Les meilleures stations d'épinette blanche (85 à 95 pieds de hauteur à 80 ans) sont celles où les sols superficiels sont bien drainés et reposent sur de la roche-mère d'origine alluviale, d'origine alluviale lacustre et sur du till.

3. Des stations moins productives que les précédentes (75 à 84 pieds de hauteur à 80 ans) sont établies sur des sols superficiels imparfaitement ou mal drainés, qui reposent sur des couches d'argile d'origine lacustre ou de roche-mère d'origine alluviale lacustre, ou sur des sols à drainage rapide et qui reposent sur des terrasses alluviales élevées.

4. Les stations les moins fertiles (de 50 à 74 pieds de hauteur à 80 ans) sont celles où le sol est argileux, mal drainé et humide, et celles où le sol est sableux et sec; il en est de même des tourbières très mal drainées, où la hauteur dominante des sujets âgés de 80 ans n'atteint même pas 50 pieds.

La classification consiste à répartir en plusieurs catégories, à titre expérimental, les terres forestières d'une partie de la section des bois mêlés et range les types physiographiques de stations par ordre décroissant de l'indice de fertilité, d'après la croissance maximum en hauteur de l'étage dominant dans les peuplements d'épinette. Cette classification est donc fondée sur la différentiation des roches-mères et des classes d'égouttement qui concourent à conférer aux sols différentes productivités forestières.

Appendix I

GLOSSARY[1]

Aeolian deposits—Wind laid material.

Alluvium -Water transported recently deposited material on which the soil forming processes have not acted long enough to produce distinct soil horizons.

Horizon -A layer in the soil approximately parallel to the land surface, with more or less well defined characteristics, that has been produced through the operation of soil building processes.

Lacustrine materials—Materials deposited by or settled out of lake waters.

Landform A topographic and geologic feature of the landscape, recognized and identified by its form and nature as determined by its relief and geologic materials respectively.

Land-type—A land pattern composed of repeated occurrences of a landform.

Orthic—A term used in soil classification, to denote the sub-group that typifies the central concept of the great group.

Parent material—The unconsolidated mass in which the soil develops.

Peat—Unconsolidated soil material consisting largely of undecomposed to partially decomposed organic matter accumulated under conditions of excessive moisture.

pH—A notation used to designate the relative acidity or alkalinity of soils and other materials.

Physiographic site classification—A categorization of forest land productivity using topography and soil factors as classification criteria within a homogeneous regional climate.

Profile—A vertical section of the soil through all its horizons and extending into the parent material.

Site—The edaphic, climatic, and biological environment as it affects the forest stand.

Soil moisture status—

1. Rapidly-drained—Soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions.

   Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly soils of coarse texture or soils on steep slopes.

2. Well-drained—Soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.

   Soils are usually free of mottling in the upper three feet but may be mottled *below* depths of three feet. B horizons, if present, are reddish, brownish, or yellowish.

3. Moderately well-drained—Soil moisture in excess of field capacity remains for a small but significant period of the year.

   The soils are commonly mottled in the lower B and C horizons or below a depth of two feet. The Ae horizon, if present, may be faintly mottled in fine-

[1] Several definitions are from Odynsky *et al.*, (1961).

textured soils or in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

4. Imperfectly-drained Soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

   The B and C horizons commonly are mottled; the Ae horizon, if present, may or may not be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

5. Poorly-drained—Soil moisture in excess of field capacity remains in all horizons for a large part of the year.

   The soil profiles show evidence of strong gleying. Except in high chroma parent materials the B, if present, and upper C horizons have matrix colors of low chroma. Faint mottling may occur throughout.

6. Very poorly drained—Free water remains at or within 12 inches of the surface most of the year.

   The soil profiles show evidence of very strong gleying. Subsurface horizons are of low chroma and yellowish to bluish hues. Mottling may be present but at depth in the profile. Very poorly-drained soils usually have a musky or peaty surface horizon.

Stratified—Composed of or arranged in strata or layers. The term is applied to parent materials.

Terrace A flat or undulating plain bordering a river or a lake. Many streams are bordered by a series of terraces at different levels indicating flood plains at successive periods. Some older terraces have become more or less hilly through dissection by streams or wind action.

Till –A heterogeneous mantle of stones, gravel, sand, silt and clay deposited by a glacier.

Water table The upper limit of the part of the soil or underlying material wholly saturated with water.

Appendix II

AERIAL PHOTO INTERPRETATION

1. Preliminary photo-interpretation key

The photo-interpretation of surface materials and soils is a means to forest land classification in the Mixedwood Section. The following key is presented as a preliminary guide.

1. (a) terrain flat to undulating 2
   (b) terrain rolling to hilly 3
2. (a) drainage pattern strongly developed 4
   (b) drainage pattern weakly developed or absent 5
3. (a) landforms are regular or semi-regular dunes; or long sheets or ridges; jack pine, white spruce or aspen cover ..... Aeolian sand; Heart soil series[1].
   (b) landforms irregular or jumbled 6
4. (a) erosion pattern: wide rounded gullies; black spruce-white spruce cover; aspen sparse ..... Lacustrine. Kathleen soil series.
   (b) erosion pattern: wide, rounded gullies. Flats covered by muskeg and by black spruce and tamarack stands ..... Lacustrine poorly drained. Kathleen soil series.
5. (a) flat to gently sloping; white spruce-aspen cover ..... Outwash. Clouston soil series.
   (b) drainage pattern: former stream channels evident near modern streams; white spruce-aspen-balsam poplar cover ..... Lowland alluvium. Alluvium, High Prairie soil series.
   (c) drainage pattern weakly developed; situated in elevated places adjacent to abandoned or modern stream channels, white spruce-aspen cover ..... Elevated, alluvial terraces; sandy soils; Heart soil series.
6. (a) topography rolling to hilly with knoll and kettle features, white spruce-aspen cover ..... Braeburn soil series in well-drained positions; Snipe soil series in poorly drained situations.
   (b) upland with rolling topography, often with broad slopes; white spruce-aspen cover ..... Ground moraine. Braeburn soil series.
   (c) topography rolling to hilly; sites occupy old stream channels and bays or enclosed depressions ..... Alluvial-lacustrine; Kathleen soil series.

[1] Soils on these landforms resemble these series as described in the soil survey report for the High Prairie and McLennan Sheets (Odynsky, Wynnyk, and Newton, 1952).

2. Site classification for an area near the south shore of Fawcett Lake. Twp. 72, R. 26, W. 4th.

Legend

Kt. ..... Kathleen soil series
Bb. ..... Braeburn soil series
Roman numerals indicate productivity classes from Table 2.

3. Beach Remnant. Twp. 74, R. 17, W. 4th.

REFERENCES

ALDRED, A. H. 1964. Areas of Forest Sections and Regions by Provinces in Canada. Dept. Forestry, Can., Forest Research Branch Mimeo 64-H-2.

ANON. 1951. Geological map of Alberta. Can. Dept. Mines Tech. Surv., Geol. Surv. Can. Map 1002A.

BAYROCK, L. A. 1962. Heavy minerals in till of Central Alberta. J. Alberta Soc. Petrol. Geologists, 10(4) 171-184.

BLYTH, A. W. 1952. White spruce standard volume tables for the Boreal and Sub-Alpine regions of Alberta. Canada Dept. Resources and Development, Forestry Branch Silv. Leaflet No. 60.

BOUYOUCOS, G. J. 1951. A recalibration of the hydrometer method for making analysis of soils. Agron. J. 43(9) 434-438.

DUFFY, P. J. B. 1962. The use of soil survey reports in the appraisal of forest land productivity in Alberta. For. Chron. 38(2): 208-211.

DUFFY, P. J. B. 1964a. Relationships between site factors and growth of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) in the Foothills Section of Alberta. Dept. Forestry, Can. Publication No. 1065.

DUFFY, P. J. B. 1964b. Soil moisture characteristics of two Bisequa Grey Wooded soils in west-central Alberta. Dept. Forestry, Can. Mimeo A-64-8.

FENIAK, M. 1944. Athabasca-Barrhead map-area (Summary Account). Can. Dept. Mines and Resources, Mines and Geology Branch, Geol. Surv. Paper 44-6.

HENDERSON, E. P. 1959. Surficial geology of Sturgeon Lake map-area, Alberta. Can. Dept. Mines Tech. Surv. Geol. Surv. Can. Mem. 303.

HILLS, G. A. 1952. The classification and evaluation of site for forestry. Ontario Dept. Lands and Forests, Research Report 23.

KIRBY, C. L. 1962. The growth and yield of white spruce-aspen stands in Saskatchewan. Saskatchewan Dept. Natural Resources, Forestry Branch Technical Bulletin No. 4.

LINDSAY, J. D., P. K. HERINGA, S. PAWLUK, and W. ODYNSKY. 1958. Exploratory soil survey of Alberta Map Sheets 84-C (east half), 84-B, 84-A, and 74-D. Research Council of Alberta Preliminary Soil Survey Report 58-1.

LINDSAY, J. D., S. PAWLUK, and W. ODYNSKY. 1959. Exploratory soil survey of Alberta Map Sheets 84-D (north half), 84-E, 84-F, and 84-G. (Appendix by L. A. Bayrock). Research Council of Alberta Preliminary Soil Survey Report 59-1.

LINDSAY, J. D., S. PAWLUK, and W. ODYNSKY. 1960. Exploratory soil survey of Alberta Map Sheets 84-J, 84-K, and 84-L. (Appendix by L. A. Bayrock). Research Council of Alberta Preliminary Soil Survey Report 60-1.

LINDSAY, J. D., S. PAWLUK, and W. ODYNSKY. 1962. Exploratory soil survey of Alberta Map Sheets 84-P, 84-I, and 84-H. (Appendix by L. A. Bayrock). Research Council of Alberta Preliminary Soil Survey Report 62-1.

MACLEOD, W. K. and A. W. BLYTH. 1955. Yield of even-aged fully stocked spruce-poplar stands in northern Alberta. Can. Dept. Northern Affairs Nat. Resources, Forestry Branch, Forest Research Division Tech. Note No. 18.

MOSS, E. H. 1959. Flora of Alberta. University of Toronto Press.

MUTTIT, G. H. 1961. Spring and summer rainfall patterns in Alberta. Can. Dept. Transport, Meteorological Branch, Circular 3512, TEC 1961.

NATIONAL SOIL SURVEY COMMITTEE OF CANADA. 1963. Report of the Fifth Meeting of the National Soil Survey Committee of Canada, University of Manitoba, Winnipeg, Man.

ODYNSKY, W. and J. D. NEWTON. 1950. Soil survey of the Rycroft and Watino Sheets. University of Alberta Bulletin No. 53.

ODYNSKY, W., A. WYNNYK and J. D. NEWTON. 1952. Reconnaissance soil survey of the High Prairie and McLennan Sheets. University of Alberta Bulletin No. 59.

ODYNSKY, W., A. WYNNYK and J. D. NEWTON. 1956. Reconnaissance soil survey of the Grande Prairie and Sturgeon Lake Sheets. University of Alberta Bulletin No. 60.

ODYNSKY, W., J. D. LINDSAY, S. W. REEDER and A. WYNNYK. 1961. Reconnaissance soil survey of the Beaverlodge and Blueberry Mountain Sheets. University of Alberta Bulletin No. SS-3.

PAWLUK, S. 1961. Mineralogical composition of some Grey Wooded soils developed from glacial till. Can. J. Soil Sci. 41:228-240.

ROWE, J. S. 1959. Forest regions of Canada. Can. Dept. Northern Affairs Nat. Resources, Forestry Branch Bulletin 123.

STALKER, A. M. 1960. Surficial geology of the Red Deer-Stettler Map Area, Alberta. Can. Dept. Mines Tech. Surv. Geol. Surv. Can. Mem. 306.

TAYLOR, R. S. 1960. Some Pleistocene lakes of northern Alberta and adjacent areas (revised). J. Alberta Soc. Petrol. Geologists 8(6): 167-185.

WATSON, E. V. 1959. British mosses and liverworts. Cambridge University Press.